power density of the incident planar illumination beam due to the fact that the width of the planar laser illumination beam <u>increases</u> for increasing distances away from the imaging subsystem.

On Page 7, please amend the second paragraph as follows:

Another object of the present invention is to provide a planar laser illumination and substantially-monochromatic imaging system, <u>wherein</u> the principle of Gaussian summation of light intensity distributions is employed to produce a planar laser illumination beam having a power density across the width the beam which is substantially the same for both far and near fields of the system.

On Page 8, please amend the fifth paragraph as follows:

Another object of the present invention is to provide such system in which [lasers] <u>laser</u> beams having multiple wavelengths are used to sense packages having a wide range of <u>surface</u> reflectivity characteristics.

On Page 9, please amend the first full paragraph as follows:

In each illustrative embodiment of the present invention, the substantially planar laser illumination beams are preferably produced from a planar laser illumination beam array (PLIA) comprising [an] <u>a</u> plurality of planar laser illumination modules (PLIMs). Each PLIM comprises a visible laser diode [(VLD] <u>(VLD)</u>, a focusing lens, and a cylindrical optical element arranged therewith. The individual planar laser illumination beam components produced from each PLIM are optically combined within the PLIA to produce a composite substantially planar laser illumination beam having substantially uniform power density characteristics over the entire spatial [extend] <u>extent</u> thereof and thus the working range of the system.

On Page 13, please amend the eighth paragraph as follows:

Fig. 1J2 is a geometrical optics model for the imaging subsystem and linear image detection array employed in <u>the</u> linear-type image detection array employed in the image formation and detection module in the PLIIM system of the first generalized embodiment shown in Fig. 1A;

On Page 14, please amend the sixth paragraph as follows:

Fig. 1K2 is a schematic representation illustrating how the field of view of a PLIIM system can be fixed to substantially match the scan field width of a low profile scanning field slightly above the conveyor belt surface, by [fixed] <u>fixing</u> the focal length of the imaging subsystem during the optical design stage;

On Page 18, please amend the second paragraph as follows:

Fig. 1V4 is a schematic representation of [an over-the-conveyor belt package identification] <u>a hand-held image-based bar code reading</u> system embodying the PLIIM system of Fig. 1V1;

On Page 36, please amend fourth paragraph as follows:

Fig. 14A is a cross-sectional view of the unitary package dimensioning and identification system of the third illustrative embodiment, taken along line <u>14A-14A</u> [184-184] in Fig. 13, showing the PLIIM subsystem contained within a first optically isolated compartment formed the unitary system housing, and the LDIP subsystem contained within a second optically isolated compartment formed therein, wherein a first set of spatially registered light transmission apertures are formed through the panels of both the first and second cavities to enable the PLIIM system to project its planar laser illumination beams towards a target object to be illuminated and collect and receive laser return light off the illuminated object, and wherein a second set of light transmission apertures, optically isolated from the first set of light transmission apertures, are formed in the second cavity to enable the LDIP subsystem to project its dual amplitude-modulated laser beams towards a target object to be dimensioned and profiled, and also to collect and receive laser return light reflected off the illuminated target object;

On Page 42, please amend the second full paragraph as follows:

The distance from the imaging lens 3B to the image detecting (i.e. sensing) array 3A is referred to as the image distance. The distance from the target object 4 to the imaging lens 3B is called the object distance. The relationship between the object distance (where the object resides) and the image distance (at which the image detection array is mounted) is a function of the characteristics of the imaging lens, and assuming a thin lens, is determined by the thin

(imaging) lens equation (1) defined below in greater detail. Depending on the image distance, light reflected from a target object at the object distance will be brought into sharp focus on the detection array plane. If the image distance remains constant and the target object is moved to a new object distance, then the imaging lens might not be able to bring the light reflected off the target object (at this new distance) into sharp focus. An image formation and detection (IFD) module having an imaging lens with fixed focal distance cannot adjust its image distance to compensate for a change in the target's object distance; all the component lens elements in the imaging subsystem remain stationary. Therefore, the depth of field (DOF) of the imaging subsystems alone must be sufficient to accommodate all possible object distances and orientations. Such basic optical terms and concepts will be discussed in more formal detail hereinafter with reference to Figs. 1J1 and 1J6.

On Page 43, please amend the first full paragraph as follows:

In accordance with the present invention, the planar laser illumination arrays 6A and 6B , the linear image formation and detection module [3 ,] 3, and any non-moving FOV and/or planar laser illumination beam folding mirrors employed in any particular system configuration described herein, are fixedly mounted on an optical bench 8 or chassis so as to prevent any relative motion (which might be caused by vibration or temperature changes) between: (i) the image forming optics (e.g. imaging lens) within the image formation and detection module 3 and any stationary FOV folding mirrors employed therewith; and (ii) each planar laser illumination array (i.e. VLD/cylindrical lens assembly) 6A, 6B and any planar laser illumination beam folding mirrors employed in the PLIIM system configuration. Preferably, the chassis assembly should provide for easy and secure alignment of all optical components employed in the planar laser illumination arrays 6A and 6B as well as the image formation and detection module 3, as well as be easy to manufacture, service and repair. Also, this PLIIM system 1 employs the general "planar laser illumination" and "focus beam at farthest object distance (FBAFOD)" principles described above. Various illustrative embodiments of this generalized PLIIM system will be described below.

On Page 45, please amend the second paragraph as follows:

As shown in Fig. 1G8, each planar laser illumination array (PLIA) 6A, [6Bemployed] 6B employed in the PLIIM system of Fig. 1G1, comprises an array of planar laser illumination modules (PLIMs) 11 mounted on the L-bracket structure 32, as described hereinabove. As

shown in Figs. 1G9 through 1G11, each PLIM of the illustrative embodiment disclosed herein comprises an assembly of subcomponents: a VLD mounting block 14 having a tubular geometry with a hollow central bore 14A formed entirely therethrough, and a v-shaped notch 14B formed on one end thereof; a visible laser diode (VLD) 13 (e.g. Mitsubishi ML1XX6 Series high-power 658nm AlGaInP semiconductor laser) axially mounted at the end of the VLD mounting block, opposite the v-shaped notch 14B, so that the laser beam produced from the VLD 13 is aligned substantially along the central axis of the central bore 14A; a cylindrical lens 16, made of optical glass (e.g. borosilicate) or plastic having the optical characteristics specified, for example, in Figs. 1G1 and 1G2, and fixedly mounted within the V-shaped notch 14B at the end of the VLD mounting block 14, using an optical cement or other lens fastening means, so that the central axis of the cylindrical lens 16 is oriented substantially perpendicular to the optical axis of the central bore 14A; and a focusing lens 15, made of central glass (e.g. borosilicate) or plastic having the optical characteristics shown, for example, in Figs. IH and 1H2, mounted within the central bore 14A of the VLD mounting block 14 so that the optical axis of the focusing lens 15 is substantially aligned with the central axis of the bore 14A, and located at a distance from the VLD which causes the laser beam output from the VLD 13 to be converging in the direction of the cylindrical lens 16. Notably, the function of the cylindrical lens 16 is to disperse (i.e. spread) the focused laser beam from focusing lens 15 along the plane in which the cylindrical lens 16 has curvature, as shown in Fig. [1I1while] <u>1I1 while</u> the characteristics of the planar laser illumination beam (PLIB) in the direction transverse to the propagation plane are determined by the focal length of the focusing lens 15, as illustrated in Figs. 1I1 and 1I2.

On Page 50, please amend the first full paragraph as follows:

As will be described in greater detail hereinafter, the focal length of the focusing lens [15within] <u>15 within</u> each PLIM hereof is preferably selected so that the substantially planar laser illumination beam produced from the cylindrical lens 16 is focused at the farthest object distance in the field of view of the image formation and detection module 3, as shown in Fig. 1I2, in accordance with the "FBAFOD" principle of the present invention. As shown in the exemplary embodiment of Figs. 1I1 and 1I2, wherein each PLIM has maximum object distance of about 61 inches (i.e. 155 centimeters), and the cross-sectional dimension of the planar laser illumination beam emerging from the cylindrical lens 16, in the non-spreading (height) direction, oriented normal to the propagation plane as defined above, is about 0.15 centimeters and ultimately focused down to about 0.06 centimeters at the maximal object distance (i.e. the farthest distance at which the system is designed to capture images). The behavior of the height

dimension of the planar laser illumination beam is determined by the focal length of the focusing lens 15 embodied within the PLIM. Proper selection of the focal length of the focusing lens 15 in each PLIM and the distance between the VLD 13 and the focusing lens 15B [indicated by reference No. (D)], can be determined using the thin lens equation (1) below and the maximum object distance required by the PLIIM system, typically specified by the end-user. As will be explained in greater detail hereinbelow, this preferred method of VLD focusing helps compensate for decreases in the power density of the incident planar laser illumination beam (on target objects) due to the fact that the width of the planar laser illumination beam increases in length for increasing distances away from the imaging subsystem (i.e. object distances).

On Page 51, please amend the first full paragraph as follows:

While a refractive-type cylindrical lens element 16 has been shown mounted at the end of each PLIM of the illustrative embodiments, it is understood each cylindrical lens element can be realized using refractive, reflective and/or diffractive technology and devices, including reflection and transmission type holographic optical elements (HOEs) well know in the art and described in detail in published International Application No. WO 99/57579 [11/11/99 [108-010PCT000]] <u>on November 11, 1999</u>, incorporated herein by reference. The only requirement of the optical element mounted at the end of each PLIM is that it has sufficient optical properties to convert a focusing laser beam transmitted therethrough, into a laser beam which expands or otherwise spreads out only along a single plane of propagation, while the laser beam is substantially unaltered (i.e. neither compressed or expanded) in the direction normal to the propagation plane. As used hereinafter and in the claims, the terms "cylindrical lens", "cylindrical lens element" and "cylindrical optical element (COE)" shall be deemed to embrace all such alternative embodiments of this aspect of the present invention.

On Page 63, please amend the second full paragraph as follows:

In Fig. 1Q1, the second illustrative embodiment of the PLIIM system of Figs. 1A is shown comprising: a 1-D type image formation and detection (IFD) module 3', as shown in Fig. 1B1; and a pair of planar laser illumination arrays 6A and [6B .] <u>6B.</u> As shown, these arrays 6A and 6B are arranged in relation to the image formation and detection module 3 so that the field of view thereof is oriented in a direction that is coplanar with the planes of laser illumination produced by the planar illumination arrays, without using any laser beam or field of view folding mirrors. One primary advantage of this system architecture is that it does not require any laser

beam or FOV folding mirrors, employs the few optical surfaces, and maximizes the return of laser light, and is easy to align. However, it is expected that this system design will most likely require a system housing having a height dimension which is greater than the height dimension required by the system design shown in Fig. 1B1.

On Page 67, please amend the second full paragraph as follows:

A fixed focal distance PLIIM system generally takes up less space than a variable or dynamic focus model because more advanced focusing methods require more complicated optics and electronics, and additional components such as motors. For this reason, fixed focus PLIIM systems are good choices for handheld and presentation scanners as indicated in Fig. 1U, wherein space and weight are always critical characteristics. In these applications, however, the object distance can vary over a range from several to a twelve or more inches, and so the designer must exercise care to ensure that the scanner's depth of field (DOF) alone will be sufficient to accommodate all possible variations in target object distance and orientation. Also, because a fixed focus imaging subsystem implies a fixed focal length camera lens, <u>and</u> the variation in object distance implies that the dots per inch resolution of the image will vary as well. The focal length of the imaging lens must be chosen so that the angular width of the field of view (FOV) is narrow enough <u>so</u> that the dpi image resolution will not fall below the minimum acceptable value anywhere within the range of object distances supported by the PLIIM system.

On Page 70, please amend the first full paragraph as follows:

The fixed focal length PLIIM system shown in Figs. 1V1-1V3 has a 3-D fixed field of view which, while spatially-aligned with a composite planar laser illumination beam 12 in a coplanar manner, is automatically swept over a 3-D scanning region within which bar code symbols and other graphical indicia 4 may be illuminated and imaged in accordance with the principles of the present invention. As such, this generalized embodiment of the present invention is ideally suited for use in hand-supportable and hands-free presentation type bar code symbol readers shown in Figs. 1V4 and 1V5, respectively, in which rasterlike-scanning (i.e. up and down) patterns can be used for reading 1-D as well as 2-D bar code symbologies such as the PDF 147 symbology. In general, the PLIM system of this generalized embodiment may have any of the housing form factors disclosed and described in Applicant's copending US Application Nos. 09/204,176 [entitled] filed December 3, 1998 and 09/452,976 filed December

2, 1999, and WIPO Publication No. WO 00/33239 published June 8, 2000, incorporated herein by reference. The beam sweeping technology disclosed in copending Application No. 08/931,691 filed September 16, 1997, incorporated herein by reference, can be used to uniformly sweep both the planar laser illumination beam and linear FOV in a coplanar manner during illumination and imaging operations.

On Page 88, please amend the first full paragraph as follows:

A preferred implementation of the image subsystem of Fig. 3C2 is shown in Fig. 3D. As shown in Fig. 3D, imaging subsystem 3B" comprises: an optical bench 3D having a pair of rails, along which mounted optical elements are translated; a linear CCD-type image detection array 3A (e.g. Piranha Model Nos. CT-P4, or CL-P4 High-Speed CCD Line Scan Camera, from Dalsa, Inc. USA—http:/www/dalsa.com) fixedly mounted to one end of the optical bench; a system of stationary lenses 3A1 fixedly mounted before the CCD-type linear image detection array 3A; a first system of movable lenses 3B1 slidably mounted to the rails of the optical bench 3D by a set of ball bearings, and designed for stepped movement relative to the stationary lens subsystem 3A1 with translator 3C1 in automatic response to a first set of control signals 3E1 generated by the system controller 22; and a second system of movable lenses 3B2 slidably mounted to the rails of the optical bench by way of a second set of ball bearings, and designed for stepped movements relative to the first system of movable lenses 3B with translator 3C2 in automatic response to a second set of control signals 3D2 generated by the system controller 22. As shown in Fig. 3D, a large stepper wheel 42 driven by a zoom stepper motor 43 engages a portion of the zoom lens system 3B1 to move the same along the optical axis of the stationary lens system 3A1 in response to control signals 3C1 generated from the system controller 22. Similarly, a small stepper wheel 44 driven by a focus stepper motor 45 engages a portion of the focus lens system 3B2 to move the same along the optical axis of the stationary lens system [3A1in] 3A1 in response to control signals 3E2 generated from the system controller 22.

On Page 94, please amend the third paragraph as follows:

As shown in Fig. 3F2, the PLIIM system of Fig. 3F1 comprises: planar laser illumination arrays 6A and 6B, each having a plurality of planar laser illumination modules 11A through 11F, and each planar laser illumination module being driven by a VLD driver circuit 18; linear-type image formation and detection module [3A;;] 3A; a pair of planar laser illumination beam

folding mirrors 37A and 37B, for folding the planar laser illumination beams 7A and 7B in the imaging direction; an image frame grabber 19 operably connected to the linear-type image formation and detection module 3", for accessing 1-D images (i.e. 1-D digital image data sets) therefrom and building a 2-D digital image of the object being illuminated by the planar laser illumination arrays 6A and 6B; an image data buffer (e.g. VRAM) 20 for buffering 2-D images received from the image frame grabber 19; a decode image processor 21, operably connected to the image data buffer 20, for carrying out image processing algorithms (including bar code symbol decoding algorithms) and operators on digital images stored within the image data buffer; and a system controller 22 operably connected to the various components within the system for controlling the operation thereof in an orchestrated manner.

On Page 101, please amend the first full paragraph as follows:

As the PLIIM systems shown in Figs. 3J1 through 3J4 employ (i) an IFD module having a linear image detecting array and an imaging subsystem having variable focal length (zoom) and variable focal distance control mechanisms, and also (ii) a mechanism for automatically sweeping both the planar (2-D) FOV and planar laser illumination beam through a 3-D scanning field in a raster-like pattern while maintaining the inventive principle of "laser-beam/FOV coplanarity" herein disclosed, such PLIIM systems are good candidates for use in a hand-held scanner application, shown in Fig. 3J5, and the hands-free presentation scanner application illustrated in Fig. 3J6. As such, these embodiments of the present invention are ideally suited for use in hand-supportable and presentation-type hold-under bar code symbol reading applications shown in Figs. 3J5 and 3J6, respectively, in which raster--like ("up and down") scanning patterns can be used for reading 1-D as well as 2-D bar code symbologies such as the PDF 147 symbology. In general, the PLIM system of this generalized embodiment may have any of the housing form factors disclosed and described in Applicant's copending US Application No. [09/204,17+] <u>09/204,176</u> filed December 3, 1998, U.S. Application No. 09/452,976 filed [December 2,,] <u>December 2,</u> 1999, and WIPO Publication No. WO 00/33239 published June 8, 2000 incorporated herein by reference. The beam sweeping technology disclosed in copending Application No. 08/931691 filed September 16, 1997, incorporated herein by reference, can be used to uniformly sweep both the planar laser illumination beam and linear FOV in a coplanar manner during illumination and imaging operations.

On Page 122, please amend the third paragraph as follows:

As shown in Fig. 10, the unitary system 120 of the present invention comprises an integration of subsystems, contained within a single housing of compact construction supported above the conveyor belt of a high-speed conveyor subsystem 121, by way of a support frame or like structure. In the illustrative embodiment, the conveyor subsystem 121 has a conveyor belt width of at least 48 inches to support one or more package transport lanes along the conveyor belt. As shown in Fig. 10, the unitary system comprises four primary subsystem components, namely: (1) a LADAR-based package imaging, detecting and dimensioning subsystem 122 capable of collecting range data from objects on the conveyor belt using a pair of multi-wavelength (i.e. containing visible and IR spectral components) laser scanning beams projected at different angular spacing as taught in copending US Application No. 09/327,756 filed June 7, 1999, supra; and [International PCT Application No. PCT/US00/15624 filed December 7, 2000] <u>WIPO Publication WO 00/75856 A1 published December 14, 2000</u>, incorporated herein by reference; (2) a PLIIM-based bar code symbol reading subsystem 25' for producing a 3-D scanning volume above the conveyor belt, for scanning bar codes on packages transported therealong; (3) an input/output subsystem 127 for managing the inputs to and output from the unitary system; and (4) a data management computer 129 with a graphical user interface (GUI) 130, for realizing a data element queuing, handling and processing subsystem 131, as well as other data and system management functions.

On Page 123, please amend the first full paragraph as follows:

As shown in Fig. 10, the package imaging, detecting and dimensioning subsystem 122 comprises a number of subsystems integrated therewithin as shown, namely: a package velocity measurement subsystem 123, for measuring the velocity of transported packages by analyzing range data maps generated by the different scanning beams, using the inventive methods disclosed in [International PCT Application No. PCT/US00/15624 filed December 7, 2000] <u>WIPO Publication WO 00/75856 A1 published December 14, 2000</u>; a package-in-the-tunnel (PITT) indication subsystem 125, for automatically detecting the presence of each package moving through the scanning volume by reflecting a portion of one of the laser scanning beams across the width of the conveyor belt in a retro-reflective manner and then analyzing the return signal using first derivative and thresholding techniques disclosed in [International PCT Application No. PCT/US00/15624 filed December 7, 2000] <u>WIPO Publication WO 00/75856 A1 published December 14, 2000</u>; a package (x-y) height/width/length dimensioning (or profiling) subsystem 124, integrated within subsystem 122, for producing x,y,z profile data sets for

detected packages; and a package-out-of-the-tunnel (POOT) indication subsystem 125, integrated within subsystem 122, realized using predictive techniques based on the output of the PITT indication subsystem 125, for automatically detecting the presence of packages moving out of the scanning volume. As shown in Fig. 10, the unitary system 120 is adapted to receive data inputs from a number of input devices including, for example: weighing-in-motion subsystem 132 for weighing packages as they are transported along the conveyor belt; an RF-tag reading subsystem for reading RF tags on packages as they are transported along the conveyor belt; etc.